

熊本大学学術リポジトリ

Kumamoto University Repository System

Title	Molding Wood-based Composites I : Mechanical and Dimensional Stability Properties
Author(s)	Yang, Ping; Sasaki, Hikaru; Pulido, Orlando; Abdul-Kader, Razali
Citation	熊本大学教育学部紀要 自然科学, 43: 117-123
Issue date	1994-09-30
Type	Departmental Bulletin Paper
URL	http://hdl.handle.net/2298/2285
Right	

Molding Wood-based Composites I Mechanical and Dimensional Stability Properties

Ping YANG, Hikaru SASAKI*, Orlando PULIDO**, and Razali ABDUL-KADER***

(Received May 23, 1994)

Abstract

This study is available on the mechanical and dimensional stability properties of moldable wood-based composites that were made from wood and polyester (PET) conjugate fibers. The experiment was designed as two groups (with or without additional of adhesive) and four formulations of wood and PET conjugate fibers (95% wood and 5% PET, 90% wood and 10% PET, 80% wood and 20% PET, and 70% wood and 30% PET). Samples cut from these composites were then tested for mechanical and dimensional stability properties. The two main factors, such as the addition of adhesive and the PET conjugate fiber content were discussed, and the optimum formulation of moldable composites was clear. The results obtained provide baseline information for tailoring product formulations to moldable wood-based composites.

Key words : molding wood-based composite, moldable material, mold-pressing, molded product

1. Introduction

Recently, the society has been focusing its attention on the technology of manufacturing complicated space molded products using a combination of wood fibers and special synthetic or inorganic fibers^{1~2)}. This technology provides a means of producing materials that take advantage of the properties of both raw materials. Advantages associated with these wood-based composite products include improved acoustic, impact, deep drawability and heat reformability properties. The processing flexibility inherent in this technology gives rise to a lot of natural and synthetic fiber products. A variety of applications are possible because of the many alternative configurations of the products. Potential products include storage bins, furniture components, automobile and truck internal parts. Such production process is usually divided into two steps as follows :

a) The manufacture of the moldable intermediate material : A variety of wood and synthetic fibers (thermoplastic fiber) are initially held together by mechanical interlocking to get a flat flexible sheet.

b) The mold-pressing : Fuse or thermoform the flat sheet into various shapes with dies.

Additional bonding of the fibers can be achieved by incorporating a thermosetting resin in the moldable intermediate material.

These composites provide options for balancing mechanical properties and moldability and material costs. The purpose of this research is to develop a database of mechanical and dimensional stability properties for these moldable wood-based composites, i. e., the moldable intermediate material. It includes investigating the effect of the adhesive and determining the optimum formula-

* Wood Research Institute, Kyoto University

** Forest Products Research and Development Institute, Philippine National Science and Technology Authority

*** Faculty of Forestry, University Pertanian Malaysia

tion of wood and polyester (PET) conjugate fibers.

2. Experiment

In this study the moldable intermediate materials were classified into two groups such as without or with resin, the former was referred to as PET conjugate fiber-bonded medium density fiberboards (PET-MDF), and the latter was phenolic formaldehyde resin-bonded MDF (PET-PF-MDF). The formulations of board construction were from 5, 10, 20, 30% PET conjugate fiber contents. So, dependent variables included two resin content levels and four PET conjugate fiber content levels. Two boards were manufactured for each combination of independent variables. The regular PF-MDF (with PF resin and without PET conjugate fiber) were also manufactured as control MDF for comparison. The target density of all boards was set at medium of 0.6g/cm³.

Wood fibers used were mixture of fibers from softwood species, predominantly sugi (*Cryptomeria japonica* D. Don.) taken from the regular production line of the Nichiha Co. Ltd. in Nagoya, Japan. Fibers were in air dry condition with 12% moisture content. To thoroughly separate and to avoid balling during the adhesive addition, fibers were passed once through a carding machine modified for wood fibers before mixing with PET conjugate fibers.

The polyester conjugate fibers were 2–3 denier, 32–102 mm long, and a bonding temperature of 110°C.

When phenolic formaldehyde resin (PF) was used, the mixture of fibers were sprayed in a drum-type rotary blender by means of a hydraulic spray gun. The resin content level was 10 percent of resin solids based upon the total formulation weight of the fibers. Mats were hand-formed on a caul plate using a forming box. A manually controlled-electronically heated press was used to densify all the boards. The pressing time applied was 6 minutes at a platen temperature of 120°C. Board thickness during pressing was controlled using stops. The dimensions of the boards were 300 mm long, 300 mm wide and 6 mm thick.

Based upon the given density level, the mechanical and dimensional stability properties of moldable wood-based composites were evaluated according to the Japan Industrial Standards for Medium Density Fiberboards (JIS A5906). Prior to mechanical and dimensional stability property testing at room temperature (about 23°C), the specimens were conditioned at 65 percent relative humidity (RH) and 20°C for about 2 weeks. Specimens had minimal exposure to ambient humidity during the time required to complete the testing. Three-point static bending modulus of elasticity (MOE) and modulus of rupture (MOR) were performed using a universal testing machine (Shinko Tsushin Kogyo Co. Ltd.). Internal bond strength (IB) was determined using a Olsen type testing machine (Tokyo Koki) with a loading rate of about 1 mm/minute. For the thickness swelling (TS) and water absorption (WA) measurements, specimens were immersed in water in a horizontal position for 24 hours at ambient temperature.

3. Experimental results and discussion

Mechanical and dimensional stability property data are presented in Figs. 1 through 7. In general, all properties depend on density, therefore the properties comparison were performed to determine differences among various PET contents and densities of specimens, because of the target

density were not achieved precisely in this experiment. Fig. 1 shows the modulus of rupture (MOR) in bending against specific gravity (SG) of PET-MDF in the presence of various PET conjugate fiber contents. MOR values were positively correlated with SG at any PET fiber content level. This trend is in agreement with regular MDF (made from wood fiber only), i. e., mechanical properties values generally increased correspondingly with density increased. However, significant differences were present among all formulations of PET-PF-MDF for different density (see Fig. 2). Only at PET content level of 10%, MOR were positively correlated with SG, whereas no correlation of MOR with SG when PET mixture ratio was 20%. Even the general trend was reversed at 5% and 30% PET content levels. This trend was that MOR decreased as SG increased. This exception can possibly be explained by the different effect of formulation on various density. It is important to balancing flexibility from PET fiber and reinforcement from wood fiber at different density levels. The same relationship between SG and other properties such as MOE, IB, TS and WA were also observed for PET-MDF and PET-PF-MDF, respectively. It is noticeable that the optimum formulation should be adjusted for a desired density when wood-based composite containing a thermoplastic fiber in combination with a thermosetting resin.

The following discussions regarding the influence of adhesive and formulation focus on general trends as reflected by rank order of property values. These values were adjusted to the nominal densities by linear regressions.

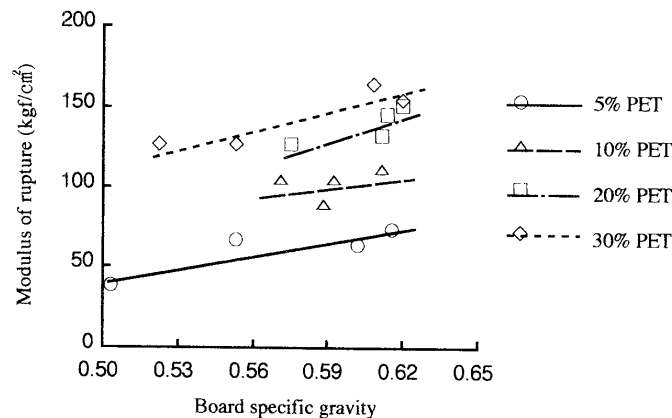


Fig. 1 Bending strength of PET-MDF.

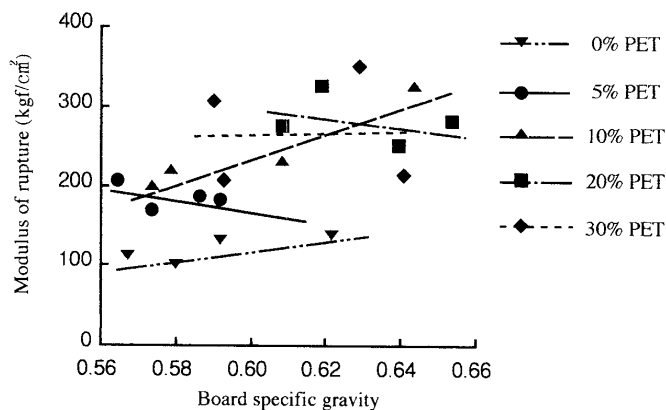


Fig. 2 Bending strength of PET-PF-MDF.

Figs. 3 and 4 show the effect of resin on MOR and MOE about PET-MDF and PET-PF-MDF, respectively. It is very clear that the properties of PET-PF-MDF were much better than those of PF-MDF at any PET content level, i. e., PET-PF-MDF exhibited consistent superiority in mechanical properties. It indicates that wood and synthetic fiber composites can benefit from an increased interfiber adhesion afforded by the addition of binder resin. When PET conjugate fiber content was under 20%, MOR and MOE of PET-MDF were positively correlated with PET conjugate fiber content, but it seems no significant effect of PET content on MOR and MOE, when PET conjugate fiber content was higher than 20%.

Internal bond strength (IB) for PET-MDF and PET-PF-MDF at all PET content levels is shown in Fig. 5. Phenolic formaldehyde resin-bonded MDF (PET-PF-MDF) generally had greater IB values than did specimens of PET conjugate fiber-bonded MDF (PET-MDF).

The ability of MDF with adhesive to seal itself was evident in either the thickness swelling (TS) and water absorption (WA) properties after a 24-hour water immersion. PET-PF-MDF were more dimensionally stable than PET-MDF (see Figs. 6 and 7) with exception of WA at 10% PET

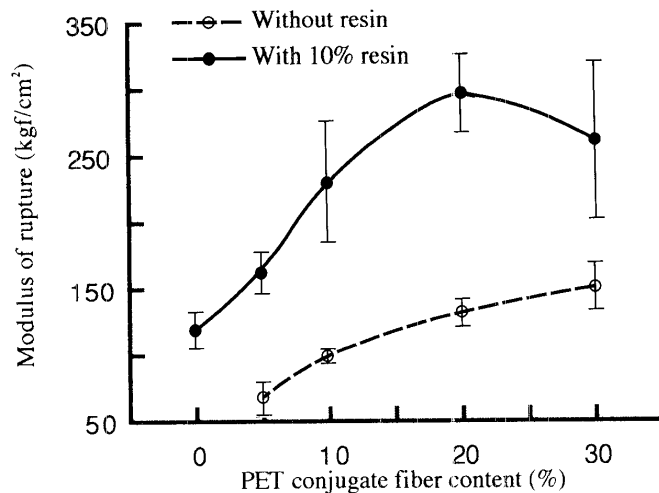


Fig. 3 Bending strength adjusted at 0.6 board specific gravity.

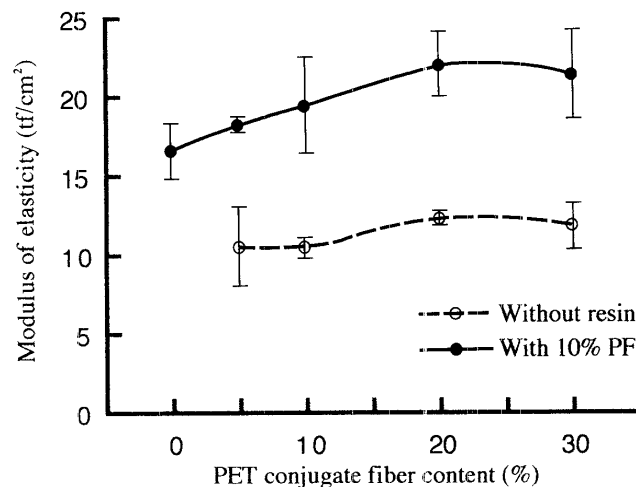


Fig. 4 Modulus of elasticity adjusted at 0.6 board specific gravity.

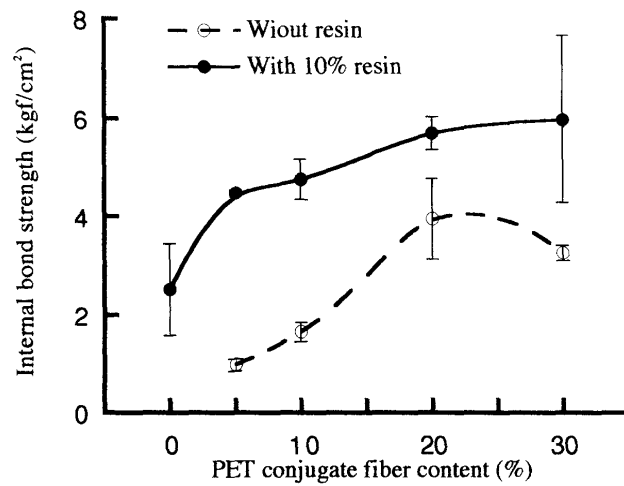


Fig. 5 Bonding strength adjusted at 0.6 board specific gravity.

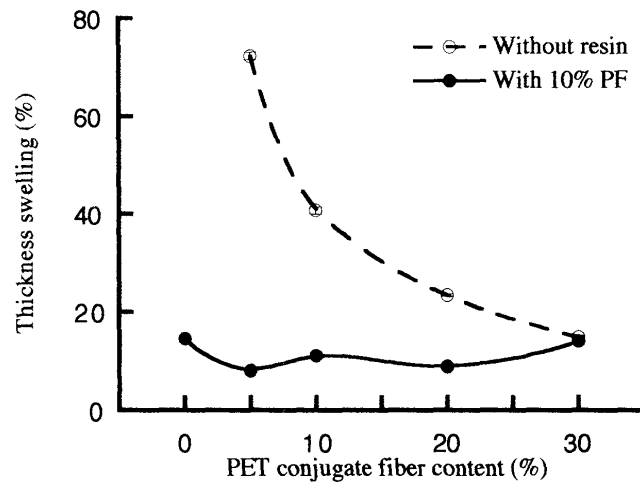


Fig. 6 Dimensional stability adjusted at 0.6 board specific gravity.

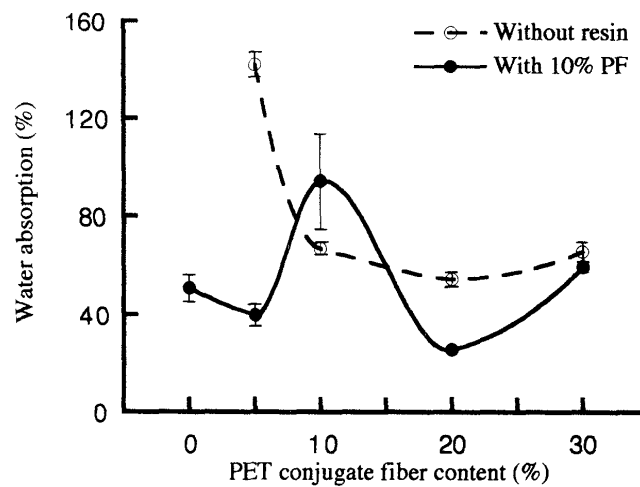


Fig. 7 Water resistance adjusted at 0.6 board specific gravity.

content level. In the case of no addition of adhesive, the MDF composite containing PET conjugate fibers had greater energy TS and WA values. It also indicates that the adhesive resin used was effective at improving interfiber bonding in a wood and polyester fiber composite.

Analysis of mechanical and dimensional stability properties data indicated that the phenolic formaldehyde resin and PET conjugate fiber play an important role in influencing all the properties of wood-based composite. With few exception, the additional resin could improve interfiber bonding in wood and PET fiber effectively. This could be described to that the resin used showed a good function just as a coupling agent between the hydrophilic wood and the hydrophobic PET fiber. Therefore, MOR, MOE, IB, TS, WA of PET-PF-MDF were 1.99–2.43, 1.73–1.78, 1.05–4.00, 1/5–1/2, 1/2–2/3 times those of PET-MDF, respectively. Regarding formulation, at target density level of 0.6 g/cm³, the optimum PET conjugate fiber content was determined at 20%. MOR, MOE, IB, TS, WA of PET-PF-MDF specimens with 20% PET content were 2.47, 1.33, 2.26, 3/5, 1/2 times those of regular PF-MDF (without PET fiber), respectively. However, mechanical and dimensional stability properties decreased with increasing of PET conjugate fiber content in further up to 30% with exception of IB.

5. Conclusion

The analyses indicated that the two main factors, phenolic formaldehyde resin (PF) and PET conjugate fiber, which play an important role in influencing the mechanical and dimensional stability properties of moldable wood-based composites. The modulus of rupture (MOR) in bending, modulus of elasticity (MOE), internal bond strength (IB), thickness swelling (TS), and water absorption (WA) of these composites could be improved by the addition of binder resin, because wood and synthetic fiber composites can benefit from increased interfiber adhesion. MOE, MOR, IB, TS, WA of PET-PF-MDF were 1.99–2.43, 1.73–1.78, 1.05–4.00, 1/5–1/2, 1/2–2/3 times than those of PET-MDF, respectively. The optimum PET conjugate fiber content was obtained at 20%, when raw materials were in this formulation, MOE, MOR, IB, TS, WA of PET-PF-MDF were 2.47, 1.33, 2.26, 3/5, 1/2 times those of regular PF-MDF, respectively. However, mechanical and dimensional stability properties decreased with increasing of PET conjugate fiber content in further up to 30% with the exception of IB. The results obtained provide guideline information that materials scientists and product designers can use to develop an array of alternative products.

Acknowledgments

This study was supported financially by a Grant-in-Aid for Developmental Scientific Research from the Ministry of Education. The authors wish to express their gratitude to the members in Wood-based Composites Laboratory of Wood Research Institute, Kyoto University for their help and valuable suggestion during the course of this research.

References

- 1) S. H. Brooks : Air lay non woven moldable mat process and products produced by using this mat

- process, Proc. of the 1990 TAPPI Nonwovens Conference, 87-108, 1990.
- 2) J. A. Youngquist, A. M. Krzysik, J. H. Muehl and C. Carl: Mechanical and physical properties of air-formed wood-fiber/polymer-fiber composites, *Forest Prod. J.* 42(6), 42-48, 1992.